Property of Lightning

INSTRUCTIONS FOR

ELECTRONIC VOLTMETER

MODEL 310A

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY

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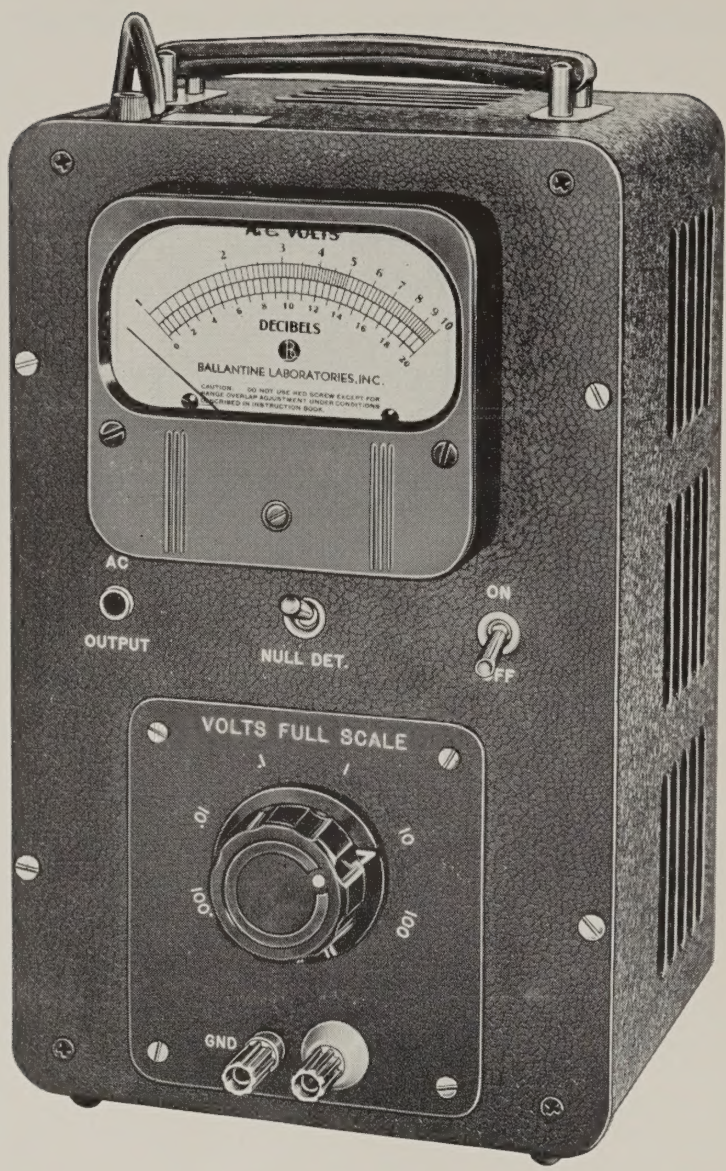
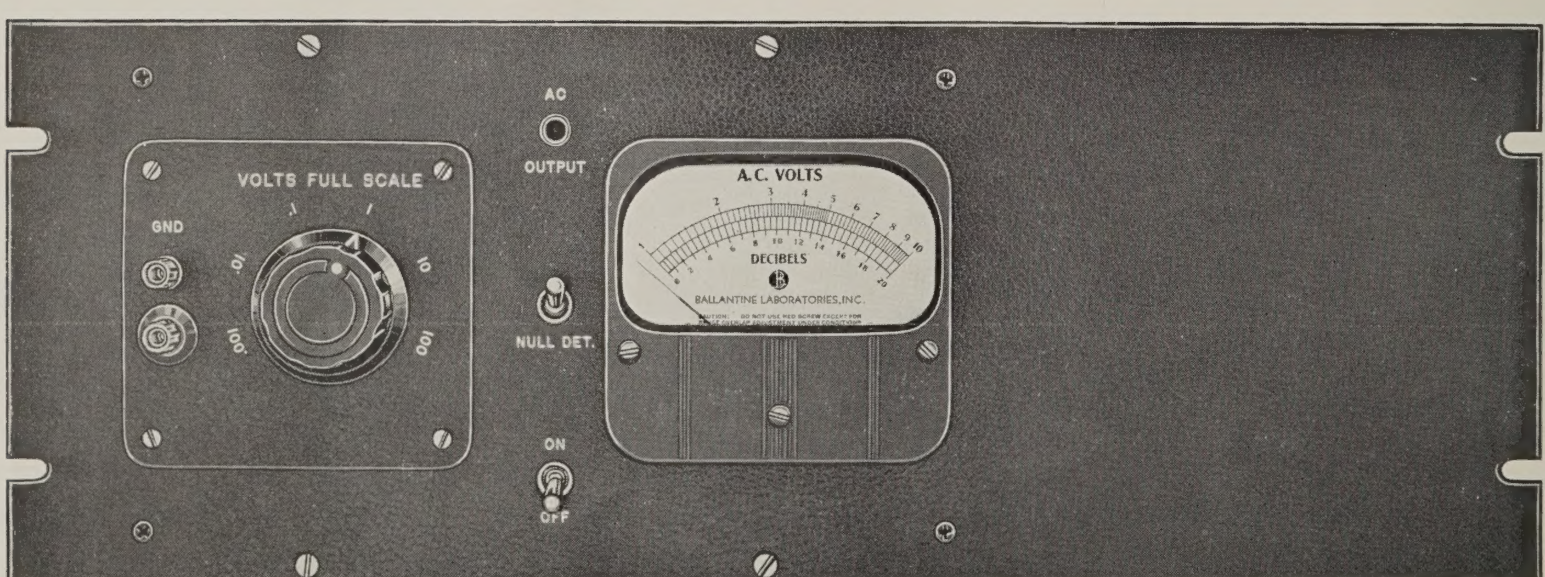


Model 310A Electronic Voltmeter



Rack Panel Mounted — Model 310A-S/2

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SPECIFICATIONS

BALLANTINE MODEL 310A ELECTRONIC VOLTMETER

Voltage Range

Direct reading from 100 microvolts to 100 volts in 6 decade ranges.
(.001, .01, .1, 1, 10, 100 volts full scale)
Measurements may be made down to 40μV at reduced accuracy when employing null detector feature. Threshold sensitivity of null detector is 10 μV.

Frequency Range

10 cps to 2 Mc for voltage measurement.
5 cps to 4 Mc as bridge null detector.

Accuracy

In range 100 microvolts to 100 volts:
3% from 10 cycles to 1 megacycle; 5% above 1 megacycle at any point on the meter scale.

Input Impedance

Range Switch Setting	Input Impedance
0.001 V and 0.01 V Ranges	2 megohms shunted by 19 pF
0.1 V Range	2.2 megohms shunted by 9 pF
1 V, 10 V and 100 V Ranges	2 megohms shunted by 9 pF

Above audio frequencies shunt resistance diminishes owing to inherent properties of all resistors having finite physical dimensions.

Scales

Logarithmic voltage scale (illuminated) reading from 1 to 10;
Linear decibel scale reading from 0 to 20
Each meter is hand calibrated.

Amplifier Characteristics

Maximum voltage gain of 60 DB, adjustable by means of range switch to 40 or 20 DB. Output impedance 500 ohms. Maximum output voltage 1 volt. Flat within ½ DB from 10 cps to 2 Mc.

Power Supply

105-125 (or 210-250) volts, 50-400 cycles, 35 watts.

Tubes

Five Type 5654; two Type OA2; one Type 6X4.
All tubes supplied.

Dimensions

Portable: 6¾″ wide, 6″ high, 10⅞″ long.
Rack Mounted: 19″ wide, 6¾″ high, 6″ deep.

Weight

11 pounds, net. Shipping weight 16 pounds.

INSTRUCTIONS FOR

BALLANTINE MODEL 310A ELECTRONIC VOLTMETER

GENERAL — This instrument is designed to measure sinusoidal voltages from 100 microvolts to 100 volts over a frequency range from 10 cycles to 2 megacycles. It operates from a 105-125 (or 210-250) volt 50 to 400 cycle power supply.

By means of a six decade range switch, the entire voltage range is indicated on a single logarithmic voltage scale reading from 1 to 10. The meter has a uniform decibel scale numbered from 0 to 20 decibels. The zero of the decibel scale is arbitrarily arranged for maximum usefulness so as to correspond to 1 on the voltage scale.

Its accuracy is 3% up to 1 megacycle and 5% above 1 megacycle.

Although the meter zero is suppressed a switch is provided for obtaining an on-scale reading when no signal is applied to the voltmeter, and this feature permits its use as a sensitive null indicator while also providing means for measuring levels below 100 microvolts down to 40 microvolts.

An AC output jack permits the amplifier section of the voltmeter to be used as a flat pre-amplifier with gains of 20, 40 or 60 DB depending on the setting of the range switch.

CIRCUIT ARRANGEMENT — The voltmeter employs a resistance-capacity decade attenuator, two negative feedback amplifier units, a full wave crystal diode rectifier and a logarithmic indicating meter responding to the average values of the voltage wave but calibrated in rms values of a sine wave. Each of the amplifier units has sufficient feedback to render the indications of the instrument substantially independent of changes in line voltage, tubes and other circuit components. Part of the range switch attenuator is placed between the two amplifier units thereby reducing tube noise, hum and microphonics to a minimum. For further circuit details see the attached diagram.

BASIC OPERATION — The voltmeter is supplied with tubes and is ready to operate as received. It is only necessary to plug the line cord into the specified AC power source and turn on the switch marked "ON-OFF." The illuminating lamps incorporated in the indicating meter serve as pilot lights to indicate when the power is on.

The input terminal marked GND is connected to the case of the voltmeter. In order to avoid the introduction of extraneous voltages between the two points whose potential difference is under measurement, the input terminal marked GND should, whenever possible, be connected to the ground of the circuit in which a voltage is being measured.

In order to avoid extraneously induced voltages when operating on the more sensitive ranges, the input leads to the voltmeter should be as short as possible and should be shielded if the consequent increase in capacitance can be tolerated. This also applies to the binding post connections and hence it is recommended that for measurements in which the avoidence of pick-up is imperative the General Radio shielded head assembly, Type 274-ND ,be employed.

Measurements in the range 100 microvolts to 100 volts are easily made by reference to the range switch position and the reading on the single voltage scale. The position of the range switch indicates the voltage input to yield full scale deflection of the indicating meter.

For best accuracy the portable version of the voltmeter should be arranged with the scale of the meter situated in the horizontal place for which position the specified accuracy figures are applicable. A degradation of accuracy by not more than 1% may occur if the instrument is used in any other position owing to unavoidable limitations of moving coil movements. In the case of rack-mounted voltmeters the specified accuracies apply for the vertical position of the panel.

MEASUREMENT BELOW 100 MICROVOLTS AND ABOVE 100 VOLTS — Although the NULL DET switch is designed for use with AC bridges, as described below, it can be employed for extending the range of the voltmeter from 100 μV down to 40 μV. The error in this region will be no greater than 10%. Whenever the pointer falls below the scale on the .001 range, depress the NULL DET switch and note the reading in microvolts. Subtract from this reading the deviation introduced by the NULL DET switch, as described below. The resulting difference represents the voltage applied to the voltmeter input. To compute the deviation introduced by the NULL DET switch, connect a signal to the voltmeter input sufficient to obtain an up-scale reading. Any range of the voltmeter can be used, and the source can be of any frequency within the range of the instrument. Ex-

press the reading in microvolts as though the instrument was on the .001 range. Now depress the NULL DET switch and again express the resulting reading in microvolts. The difference between these two readings is the deviation introduced by the NULL DET switch.

Voltages less than 100 microvolts over the range from 10 to 150,000 cycles may be measured directly with this voltmeter by using it in conjunction with the Ballantine Model 220C Decade Amplifier.

For measurements above 100 volts (200 volts in the case of the Model 310A-S/3) the Ballantine Models 1310A and 1310B Multipliers permit an increase in range to 1000 volts and 10,000 volts, respectively.

MEASUREMENT OF VOLTAGES AT LINE FREQUENCY — Even though the amount of residual hum in the voltmeter is negligible in relation to normal measurements, it may introduce slight errors when the voltmeter is used to measure voltages giving indications at the lower end of the meter scale and having a frequency synchronous with that of the AC supply. Errors due to this condition will not exceed ½% on all range settings except the .001 range where up to 3% is possible. These inaccuracies may be reduced by making two measurements, one with the power plug in normal polarity and the other with the power plug reversed. The mean of these readings will represent the true value of the voltage being measured.

INPUT IMPEDANCE — The input impedance of the voltmeter depends somewhat on the setting of the range switch as shown by the tabulation in the specifications on page 3.

Any direct current component of the wave under measurement is kept out of the voltmeter by means of a series blocking condenser in the input circuit of 600 volts DC rating. If it is desired to measure the AC or ripple component of a wave whose DC component exceeds 600 volts an auxiliary network should be employed. This may consist of a series condenser of at least 0.15 μF (with a voltage rating at least equal to the DC component of the wave under measurement) and a resistor of at least 5 megohms in shunt. An example of the use of such a network would be for the measurement of the commutator ripple on a 650 volt DC generator.

OVERLOAD CHARACTERISTICS — The amplifier circuits are designed to saturate promptly when the voltage exceeds the full scale indication of the meter, thus protecting the meter movement. This is of considerable advantage over other meters which may be seriously damaged by overloads such as the Model 310A will withstand. Overloads amounting to several hundred to one can be safely withstood on the lower ranges, while on the 10 and 100 volt ranges the maximum safe voltage is 400 volts.

EFFECT OF WAVE FORM — The indications of this voltmeter are proportional to the average value of the AC wave under measurement. Since however, it is primarily intended to measure sinusoidal waves its calibration is in terms of the rms value of a sinusoidal wave. Since electronic voltmeters of the input diode rectifier type respond to the peak values of a wave, the readings of such a meter and the present voltmeter will not necessarily agree when harmonics are present. The amount of the discrepancy will depend on the number and magnitude of the harmonics present as well as their phase relationship with respect to the fundamental. In all cases, however, the departure of the readings from true rms values due to the presence of harmonics will be considerably less with an average responding meter such as the Model 310A than with a peak responding meter. For example, in the case of a third harmonic whose amplitude is 20% of the fundamental the maximum error of a peak responding meter may be as much as 20% whereas the maximum error of an average responding meter such as the Model 310A will never exceed 6.7%.

Inasmuch as the Model 310A voltmeter responds to the average value of the AC wave, "turn-over" discrepancies occasioned by any lack of symmetry of the wave such as are experienced in half-wave peak reading instruments are minimized, provided the crest factor of the wave does not exceed 2 when readings are being made at full scale. For lower readings the crest factor limit is increased in inverse proportion to the ratio of the reading and full scale deflection.

SCALE RANGE ADJUSTMENT — Under normal conditions a voltage which produces a scale reading of 10 will, when reduced by 90% (i.e. in the ratio of 10 to 1), produce a scale reading of 1. Ordinarily no adjustment should be necessary except at very infrequent intervals, but if some discrepancy is noted an adjustment accurate to approximately 1% may be made as follows: Allow the voltmeter to warm up for at least five minutes. Connect to the input a stable AC source of about 10 volts, of less than 1% distortion, and of any convenient frequency from 100 to 10,000 c.p.s. Adjust the amplitude so that the meter reads full scale (10) on the 10 volt range. Switch to the 100 volt range. The meter should now read 1. If not,

the red adjusting screw on the indicating meter should be rotated until it does. Switch back to the 10 volt range, to see whether the meter still reads 10. If not, readjust the input voltage to read 10 and then switch back to 1, readjusting the red screw if necessary. If it is not convenient to obtain a source of 10 volts the 1 and the 10 volt ranges may be similarly used to make this adjustment by using a source of 1 volt. (Since the input resistance of the voltmeter on the 0.1 volt range is slightly higher than on the other ranges the use of this range is not recommended in making this range adjustment unless the impedance of the voltage source is less than 50,000 ohms.)

If greater accuracy than that indicated above is desired it is recommended that the scale range adjustment be made on a single range of the voltmeter by using an external precision 10:1 potential divider which presents to the voltmeter a source impedance of not more than 2,000 ohms. The procedure would then be as outlined above except that level changes would be made with the potential divider and not the voltmeter range selector switch.

METER ADJUSTING SCREW — In the past some users have misunderstood the purpose of the red adjusting screw on the case of the indicating meter and have tried to use it either to bring the pointer to 1 on the scale with no voltage applied to the voltmeter input terminals, or to change the calibration of the voltmeter, instead of realizing that its *sole* function is to effect the scale range adjustment as described in the preceding section. The indicating meter, being logarithmic, has a suppressed zero and the normal position of the pointer with no input voltage is against the left-hand stop and off scale. The meter should indicate on scale only when a voltage within the range selected by the range switch is applied to the input terminals of the instrument (except when the "Null Det." switch is operated).

CALIBRATION ADJUSTMENT — Normally, no attention need be given to the matter of calibration as the large amount of feedback in the instrument gives it sufficient inherent stability to maintain the original factory calibration within the accuracy specified. However, to correct errors which might result from the cumulative effects of wide variations in characteristics of replacement tubes from average tubes, a variable control has been provided which allows the calibration to be shifted a small amount. Access to this control is possible with a screw-driver after removing the plug button situated on the side of the voltmeter close to the amplifier output connector.

In adjusting the calibration of the instrument the source voltage should be a *pure* sinusoidal wave of any convenient frequency from 100 to 10,000 c.p.s. and the rms indicating voltmeter used as the standard should be accurate to at least 1% at the selected test frequency.

USE AS A NULL DETECTOR — Although the Model 310A voltmeter possesses adequate sensitivity to detect unbalance voltages for most bridge measurement work, a condition may arise where the unbalance voltage will be less than 100 microvolts in which case the pointer of the voltmeter will fall below the left-hand extremity of the scale when working on the 0.001 volt range. In this contingency the null balance may be consummated by depressing the null detector switch marked "Null Det." thereby supplying a small bias current to the indicating meter and bringing the pointer to an on-scale reading even in the absence of an input signal. With this switch depressed the direct-reading feature of the voltmeter is temporarily invalidated and the instrument serves only to indicate the relative magnitudes of very low potentials in the order of 10 to 100 microvolts and in a frequency range of 10 cycles to 4 megacycles (except as discussed under "Measurements Below 100 Microvolts").

USE AS AN AMPLIFIER — Inserting a standard tip and sleeve telephone plug into the output jack marked "AC OUTPUT" automatically disconnects the indicating meter and makes the amplifier section of the voltmeter usable as a stable high gain preamplifier. When the range switch is set for the 0.001 range the gain of the amplifier is 60 DB which gain may be reduced to either 40 or 20 DB by setting the range switch to the 0.01 or the 0.1 setting respectively. The maximum undistorted output of the amplifier is 1 volt and its output impedance is 500 ohms. When fed into a load having a resistance of not less than 50,000 ohms and a capacitance of 40 to 70 pF (which may be that of the output cable) the amplifier will give a response uniform within ½ DB over the entire frequency range from 10 cycles to 2 megacycles.

The hum and noise level present at the output jack when the instrument is used as an amplifier is less than 20 millivolts on the most sensitive range (0.001 volt) and less than 2 millivolts on the other ranges. These noise levels are 34 DB and 54 DB respectively down from the maximum undistorted output voltage level of 1 volt. They are equivalent to less than 20 microvolts in series with the grid of the input tube.

POWER LEVEL MEASUREMENTS — In view of the many different applications for Ballantine Voltmeters and the prevailing differences in power reference levels, it was felt inadvisable to relate the db scale of the basic instrument to any particular level.* Accordingly, in the interest of clarity and generality, the 0 of the db scale has been set arbitrarily at 1 on the voltage scale, and 20 db, therefore, corresponds to 10 on the voltage scale.

The most frequently used power references at which a level of zero decibels is arbitrarily set are:

(1) 1 mW/600 Ω — 1 milliwatt of power corresponding to 0.775 volts across a pure resistance of 600 ohms.

(2) 6 mW/600 Ω — 6 milliwatts of power corresponding to 1.897 volts across a pure resistance of 600 ohms.

(3) 6 mW/500 Ω — 6 milliwatts of power corresponding to 1.732 volts across a pure resistance of 500 ohms.

The following table enables a ready conversion from the db reading of the Ballantine Scale to the actual zero db power level for any of the reference levels above including zero db corresponding to 1 volt.

If power reference levels other than those above are involved the Ballantine Laboratories, Inc., DB Slide Rule will be found very useful in the corresponding decibel level determinations. The slide rules are available free of charge on application to the Company.

MEASUREMENT OF CURRENT — By using Ballantine Series 600 Precision Shunt Resistors in conjunction with this voltmeter currents from 0.1 microampere to 3 amperes may be measured over a frequency range of 10 cps to 200 kilocycles with an accuracy approaching that of the voltmeter. If reduced accuracy is tolerable current measurements may be also made at frequencies up to 1 megacycle within the limits stated in our catalogue description of these Precision Shunt Resistors. The lowest Shunt available for minimizing voltage drops is 0.01 ohm, which may be used to measure currents from 10 milliamperes to 10 amperes up to 20,000 cps with an introduced error of less than 0.5%.

SERVICING — Servicing of this instrument by the user is not recommended except for the renewal of the fuse, illuminating lamps and tubes.

CAUTION

Do not remove either the V5-5654 Tube or the diode assembly 310A-X2 without first either switching the instrument off or inserting a telephone plug in the amplifier output jack. Damage to the diode assembly can result if this precaution is not observed.

WARNING

However, if attempts are made to investigate the internal parts of the voltmeter potentials as high as 400 VOLTS MAY BE ENCOUNTERED with respect to the chassis. When removing the panel from the outer case of the voltmeter unscrew only the four bright oval head screws at the edges of the panel, and not the black Phillips head screws.

REPLACEMENT OF TUBES — Maintenance of accuracy within the specified limits is dependent

*To serve those who frequently work with reference to zero dbm in 600 ohm circuits a special version Model 310A-S/1 is available with the db scale related directly to this datum.

MODEL 310A RANGE SETTING	DB TO BE ADDED TO OR SUBTRACTED FROM THE DB READING ON THE BALLANTINE DB SCALE IN ORDER TO CONVERT TO THE DESIRED ZERO REFERENCE LEVEL			
Volts Full Scale	Zero Level = 1mW-600 ohm	Zero Level = 6mW-600 ohm	Zero Level = 6mW-500 ohm	Zero Level = 1 volt
0.001	−77.8	−85.6	−84.8	−80
0.01	−57.8	−65.6	−64.8	−60
0.1	−37.8	−45.6	−44.8	−40
1.0	−17.8	−25.6	−24.8	−20
10.0	+ 2.2	− 5.6	− 4.8	0
100.0	+22.2	+14.4	+15.2	+20

on the extent of tube deterioration after the voltmeter has been subjected to extensive use. Even the stabilizing effect of negative feed-back cannot completely offset severe degradation of tube characteristics, especially when a number of tubes are involved simultaneously.

A simple test can be undertaken as follows to check the overall state of the amplifier tubes and so allow the user to decide whether tube replacement is necessary.

Insert an adjustable auto-transformer (such as a Variac) between the voltmeter and the power line. Feed a stable signal of audio frequency to the voltmeter input terminals and effect adjustments to produce an on-scale deflection. Note the change in reading as the line voltage is varied between the limits 105 and 125 volts. If the change exceeds 3% it is recommended that all amplifier tubes be checked for sub-normal transconductance.

This instrument is fitted with a lamp (Type TS47) mounted between the two 0A2 regulator tubes. The illumination from this lamp aids in the firing of these tubes under conditions of low line voltage. If the instrument exhibits excessive meter flutter after being turned on for a minute or so, check for a lamp failure. Occasionally an 0A2 tube, with aging, will become sluggish in firing even with the higher light ambient provided by the lamp, and the tube should therefore be replaced.

The failure of the meter illuminating lamps to light after the switch is turned on is an indication of either burned out lamps or a blown fuse. Access to these lamps for replacement purposes may be obtained by removing the cover of the indicating meter by unscrewing the two holding screws on the top. The fuse is located on the side of the voltmeter case through which the power cord passes. It is of the cartridge type and may be replaced without removing the voltmeter from its case by merely unscrewing the thumb screw marked "Fuse." Spare fuses are supplied but if additional fuses are required they are type 3AG, ¾ ampere, and may be ordered from any standard source of fuse supply.

Specialized techniques and highly precise calibration equipment are needed for thorough servicing of the voltmeter. It is therefore stressed that any major problem concerning its operation be reported to Ballantine Laboratories, Inc. whose engineering and repair departments will give it their prompt attention and will submit suggestions to deal with the difficulty. Give full details concerning conditions of usage, including the serial number of the voltmeter.

If, after acting on recommendations given by us, the difficulty still persists, or if the defect is clearly in the voltmeter and is not eliminated by tube replacement, the voltmeter should be returned via Railway Express packed in a surrounding of at least 3 or 4 inches of excelsior or similar material.

In the case of an instrument whose period of purchase exceeds the warranty period, a reasonable charge will be made for repairs and for replacement of faulty components including defective tubes.

WARRANTY — We warrant each instrument sold by us to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes or batteries, which shall, within 1 year after shipment to the original purchaser, prove upon our examination to be defective.

REPLACEMENT PARTS LIST

REFER TO MODEL 310A SCHEMATIC DIAGRAM MC-792D

B.L. PART NO.	CIRCUIT SYMBOL	CAPACITORS	MANUFACTURER
2140	C1	.047 μF, 600 v, Type 620S,	Goodall
2453	C2	0.5-5 pF, Variable Trimmer, Type 532,	Erie
2225	C3	8 pF, Type CM15C-080-J	El-Menco
2431	C4	3-12 pF, Type TS2A-3,	Erie
2404	C5	760 pF, Max., Type X305,	El-Menco
2407	C6	1600 pF, Max., Type X309,	El-Menco
2213	C7	.004 μF, Mica, Type 1W,	Cornell-Dubilier
2201	*C8	2 pF, Mica, Type CM-15-C-020-M,	Arco
2005	C9A	15 μF, 150 v, Type DFP,	Magnavox
	C9B	15 μF, 150 v, Type DFP,	Magnavox
	C9C	1000 μF, 2 v, Type DFP,	Magnavox
2040	C10	100 μF, 150 v, Type DFP,	Magnavox
2132	C11	1 μF, 200 v, Type 621M,	Goodall
2142	C12	0.1 μF, 200 v, Type 109P10492,	Sprague
2228	C13	50 pF, Type CM15E-500J,	El-Menco
2226	C14	3 pF, Type CM15-C-030M,	El-Menco
2451	C15	1-8 pF, Ceramic Variable, Type 532,	Erie
2101	C16	0.002 μF, 600 v, Type 68P22081H,	Magnavox
2005	C17A	15 μF, 150 v, Type DFP,	Magnavox
	C17B	15 μF, 150 v, Type DFP,	Magnavox
	C17C	1000 μF, 2 v, Type DFP,	Magnavox
2139	C18	.033 μF, 200 volt, Type 621S,	Goodall
2138	C19	0.1 μF, 200 volt, Type 620S,	Goodall
2503	C20	2.2 pF, Type GA,	Stackpole
2055	C21	25 μF, 25 v, Type DPE,	Sprague
2318	C22	2 μF, 200 v, PUP, −0 +10%,	Cornell-Dubilier
2055	C23	25 μF, 25 v, Type DPE,	Sprague
2055	C24	25 μF, 25 v, Type DPE,	Sprague
2018	C25	1000 μF, 10 v, Type DFP,	Magnavox
2030	C26A	10 μF, 450 v, Type DFP,	Magnavox
	C26B	30 μF, 450 v, Type DFP,	Magnavox
2029	C27	50 μF, 350 v, Type DFP,	Magnavox
2040	C28	100 μF, 150 v, Type DFP,	Magnavox
2040	C29	100 μF, 150 v, Type DFP,	Magnavox
2040	C30	100 μF, 150 v, Type DFP,	Magnavox
2232	*C31	150 pF, Type CM15-E-151-J,	El-Menco
2235	C32	33 pF, Type CM-15-E-390-J,	El-Menco
2226	*C34	3 pF, Type CM-15-C-030-M,	Arco

* The values of these items are determined during the calibration of the instrument and may differ from the values listed.

REPLACEMENT PARTS LIST

REFER TO MODEL 310A SCHEMATIC DIAGRAM MC-792D

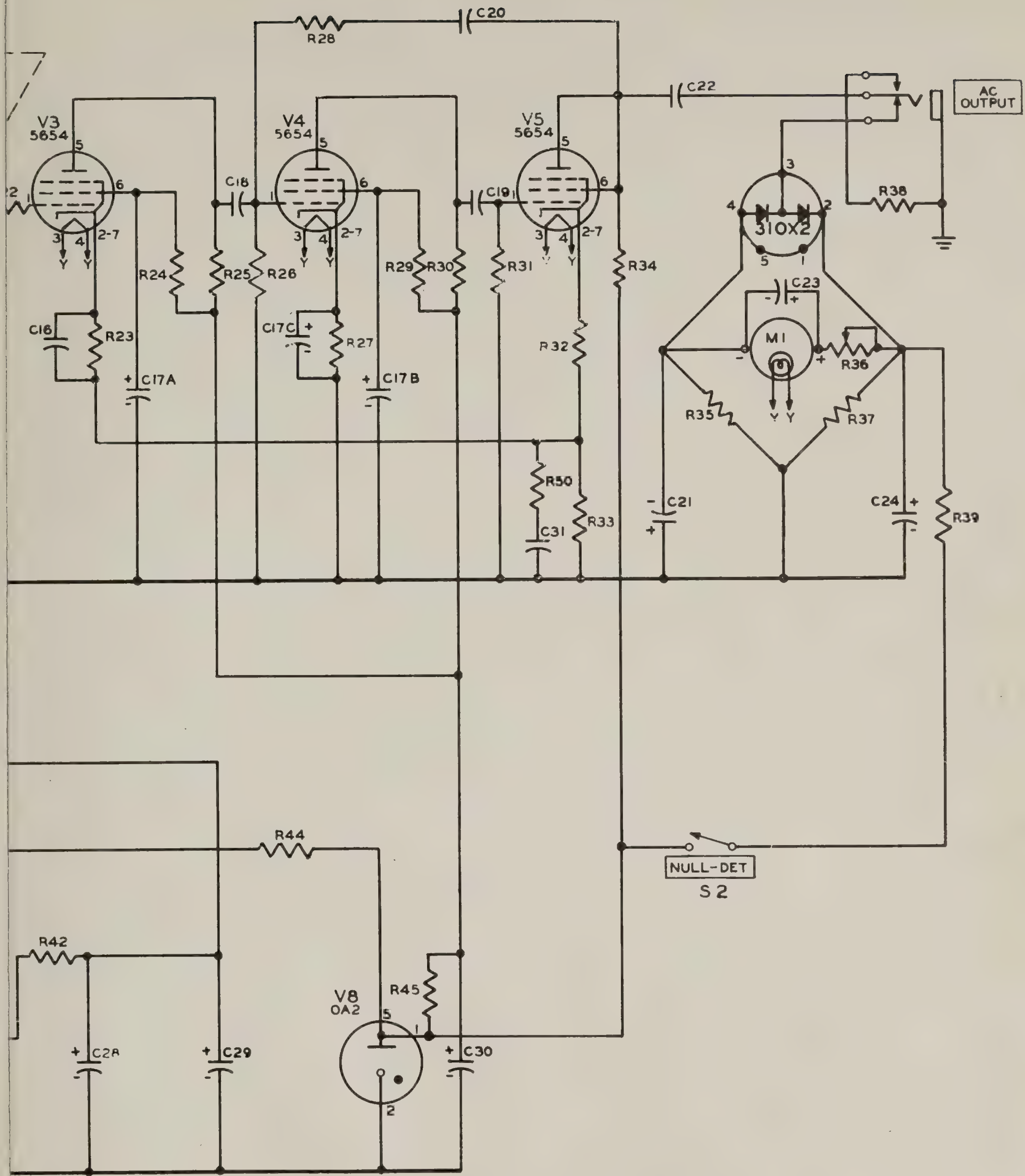
B.L. PART NO.	CIRCUIT SYMBOL	RESISTORS	MANUFACTURER
1060	R1	620 ohms, Type EB, 5%,	Allen-Bradley
1303	R2	250,000 ohms, Type CP-½, 1%,	Wilkor
1319	R3	20,400 ohms, Type CP-½, 1%,	Wilkor
1072	R4	39 ohms, Type EB, 5%,	Allen-Bradley
1335	R5	2,000 ohms, Type CP-½, 1%,	Wilkor
1260	R6	7.5 ohms, Type GB, 5%,	Allen-Bradley
1351	R7	200 ohms, Type CP-½, 1%,	Wilkor
1460	R8	2,000,000 ohms, Type CP-½, 1%,	Wilkor
1460	R9	2,000,000 ohms, Type CP-1, 1%,	Wilkor
1065	R10	200 ohms, Type EB, 5%,	Allen-Bradley
1353	R11	140 ohms, Type CP-½, 1%,	Wilkor
1041	R12	18,000 ohms, Type EB, 5%,	Allen-Bradley
1656	R13	7,500 ohms, Type N20, 1%,	Corning
1023	R14	200,000 ohms, Type EB, 5%,	Allen-Bradley
1064	R15	220 ohms, Type EB, 5%,	Allen-Bradley
1044	R16	10,000 ohms, Type EB, 5%,	Allen-Bradley
1366	R17	9,000 ohms, Type CP-½, 1%,	Wilkor
1338	R18	1,000 ohms, Type CP-½, 1%,	Wilkor
1461	R19	1,000,000 ohms, Type CP-½, 1%,	Wilkor
1308	R20	111,100 ohms, Type CP-½, 1%,	Wilkor
1060	*R21	620 ohms, Type EB, 5%,	Allen-Bradley
1065	R22	200 ohms, Type EB, 5%,	Allen-Bradley
1065	R23	200 ohms, Type EB, 5%,	Allen-Bradley
1081	R24	27,000 ohms, Type EB, 5%,	Allen-Bradley
1325	R25	7,500 ohms, Type CP-½, 1%,	Wilkor
1091	R26	91,000 ohms, Type EB, 5%,	Allen-Bradley
1082	R27	240 ohms, Type EB, 5%,	Allen-Bradley
1040	R28	20,000 ohms, Type EB, 5%,	Allen-Bradley
1081	R29	27,000 ohms, Type EB, 5%,	Allen-Bradley
1325	R30	7,500 ohms, Type CP-½, 1%,	Wilkor
1010	R31	1,000,000 ohms, Type EB, 5%,	Allen-Bradley
1345	R32	400 ohms, Type CP-½, 1%,	Wilkor
1754	R33	29.5 ohms, Special, 1%,	Ballantine
1040	R34	20,000 ohms, Type EB, 5%,	Allen-Bradley
1712	R35	2,500 ohms, Type RS-2, 1%,	Dale
1814	R36	2,000 ohms, Type W-2000 Pot,	I.R.C.
1712	R37	2,500 ohms, Type RS-2, 1%,	Dale
1342	R38	540 ohms, Type CP-½, 2%,	Wilkor
1012	R39	750,000 ohms, Type EB, 5%,	Allen-Bradley
1716	R40	800 ohms, Type 5KT, 5%,	Sprague
1717	R41	3,750 ohms, Type 5KT, 5%,	Sprague
1268	R42	1,300 ohms, Type GB, 5%,	Allen-Bradley
1706	R44	3,500 ohms, Type 5KT, 5%,	Sprague
1057	R45	1,000 ohms, Type EB, 5%,	Allen-Bradley
1062	R47	300 ohms, Type EB, 5%,	Allen-Bradley
1083	R49	82 ohms, Type EB, 10%,	Allen-Bradley
1057	*R50	1,000 ohms, Type EB, 5%,	Allen-Bradley
1026	R52	100,000 ohms, Type EB, 5%,	Allen-Bradley

* The values of these items are determined during the calibration of the instrument and may differ from the values listed.

REPLACEMENT PARTS LIST

REFER TO MODEL 310A SCHEMATIC DIAGRAM MC-792D

B.L. PART NO.	CIRCUIT SYMBOL	OTHER COMPONENTS	MANUFACTURER
3006	L1	Peaking Coil,	Ballantine
3030	T1	Power Transformer, Code 79-51R,	Ballantine
3406	F1	¾ amp. fuse, Type 3AG,	Littelfuse
3451	I1	Pilot Light, Type 47,	General Electric
3162	M1	Indicating Meter,	Ballantine
3230	S1	Range Switch,	Ballantine
3268	S2	ON-OFF Switch,	Ballantine
3269	S3	NULL DET. Switch,	Ballantine
3126	V1, 2, 3, 4, 5	Type 5654 Tube,	General Electric
3105	V6	Type 6X4 Tube,	R.C.A.
3106	V7, 8	Type 0A2 Tube,	R.C.A.
3144	CR1	Crystal Diode, Type S53,	Transitron
3075	CR2	Selenium Rectifier, Type P1B1S1A,	Radio Receptor



Sensitive Electronic Voltmeter Model 310A Issue MC-792D

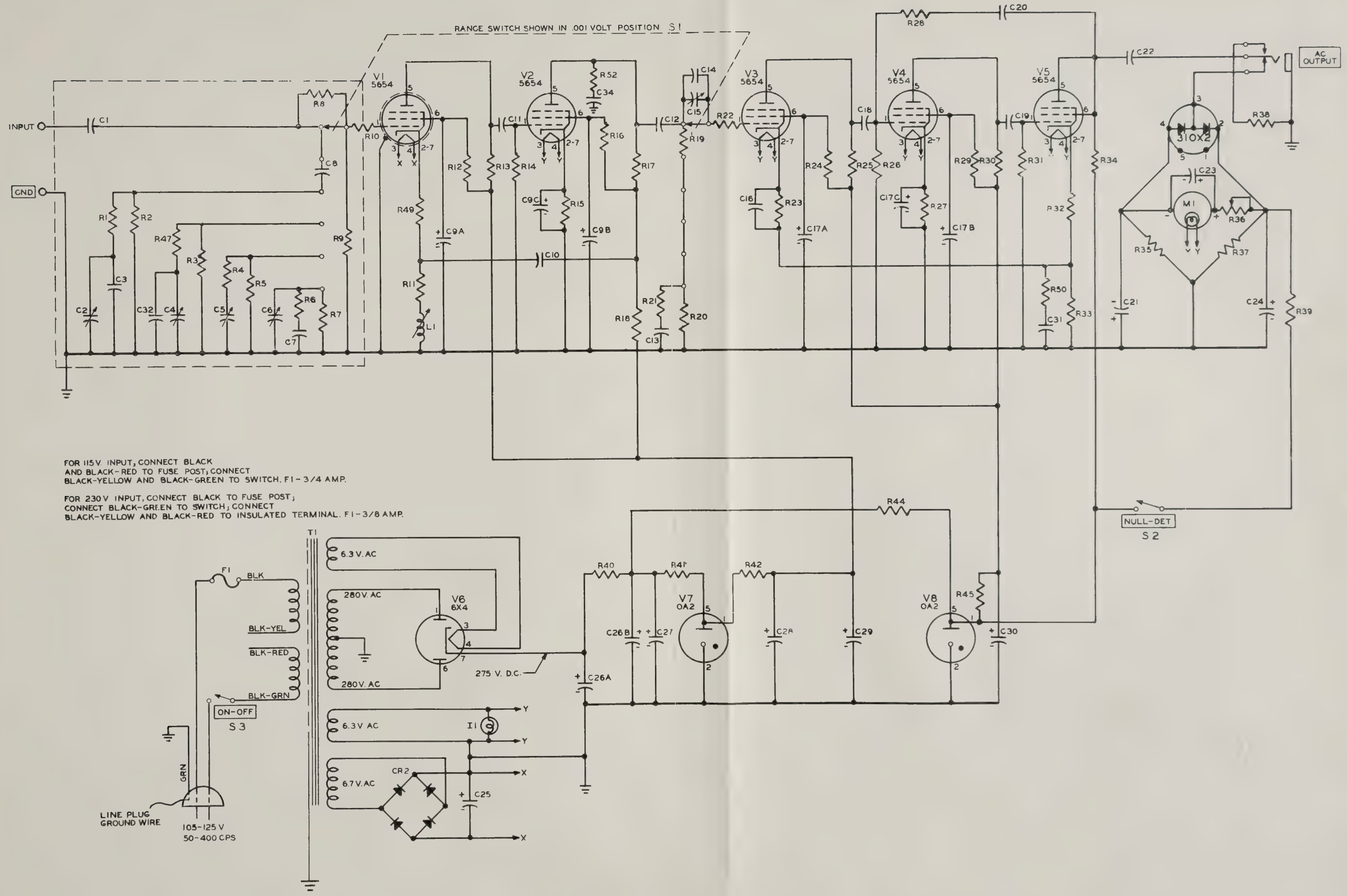
BALLANTINE LABORATORIES, INC.

BOONTON, N. J.

REPLACEMENT PARTS LIST

REFER TO MODEL 310A SCHEMATIC DIAGRAM MC-792D

B.L. PART NO.	CIRCUIT SYMBOL	OTHER COMPONENTS	MANUFACTURER
3006	L1	Peaking Coil,	Ballantine
3030	T1	Power Transformer, Code 79-51R,	Ballantine
3406	F1	¾ amp. fuse, Type 3AG,	Littelfuse
3451	I1	Pilot Light, Type 47,	General Electric
3162	M1	Indicating Meter,	Ballantine
3230	S1	Range Switch,	Ballantine
3268	S2	ON-OFF Switch,	Ballantine
3269	S3	NULL DET. Switch,	Ballantine
3126	V1, 2, 3, 4, 5	Type 5654 Tube,	General Electric
3105	V6	Type 6X4 Tube,	R.C.A.
3106	V7, 8	Type 0A2 Tube,	R.C.A.
3144	CR1	Crystal Diode, Type S53,	Transitron
3075	CR2	Selenium Rectifier, Type P1B1S1A,	Radio Receptor



FOR 115V INPUT, CONNECT BLACK AND BLACK-RED TO FUSE POST; CONNECT BLACK-YELLOW AND BLACK-GREEN TO SWITCH. F1-3/4 AMP.

FOR 230V INPUT, CONNECT BLACK TO FUSE POST; CONNECT BLACK-GREEN TO SWITCH; CONNECT BLACK-YELLOW AND BLACK-RED TO INSULATED TERMINAL. F1-3/8 AMP.

Sensitive Electronic Voltmeter Model 310A Issue MC-792D

BALLANTINE LABORATORIES, INC.
BOONTON, N. J.

INSTRUCTIONS FOR

ELECTRONIC VOLTMETER

MODEL 310A

BALLANTINE LABORATORIES, INC.

BOONTON, NEW JERSEY

Printed in U.S.A.

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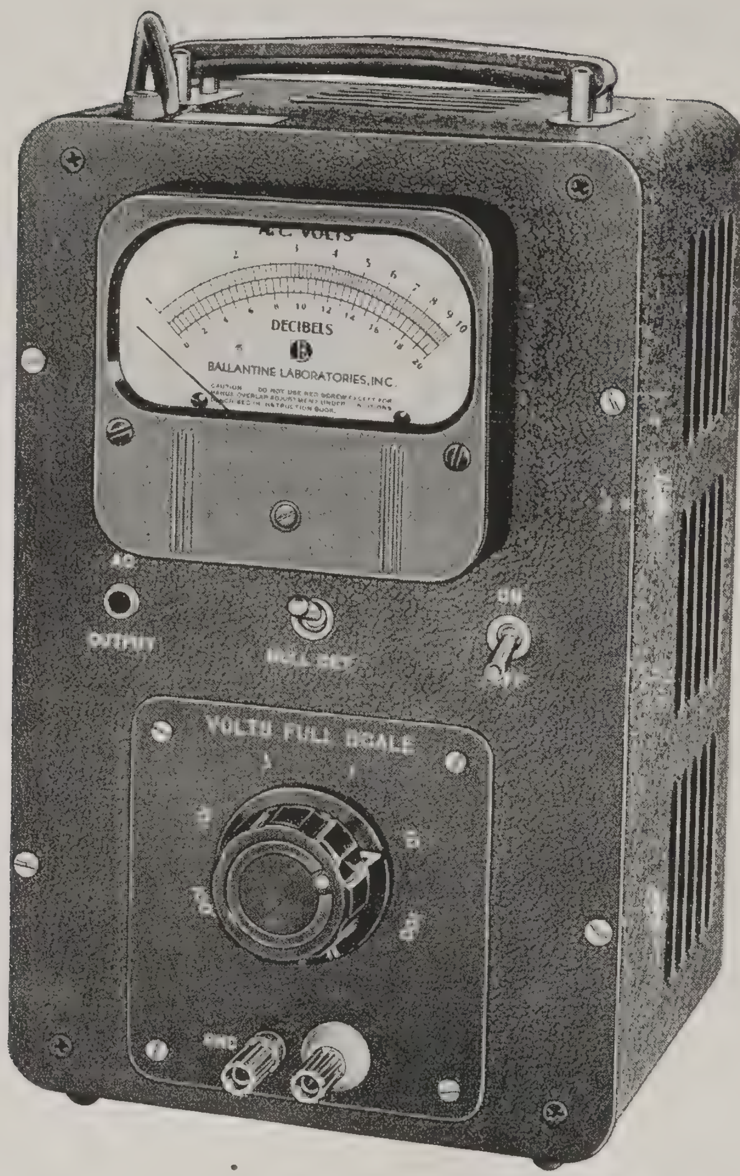
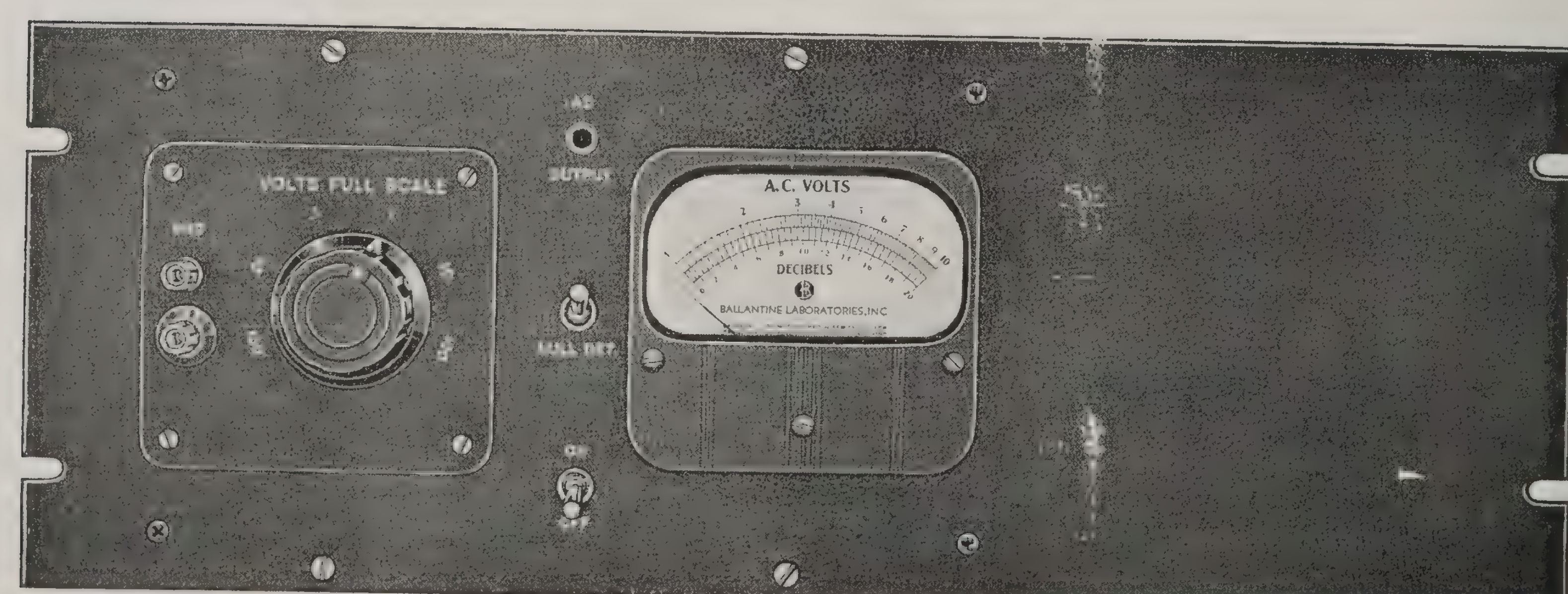


Model 310A Electronic Voltmeter



Rack Panel Mounted — Model 310A-S/2

CONTENTS

SPECIFICATIONS

BALLANTINE MODEL 310A ELECTRONIC VOLTMETER

Voltage Range

Direct reading from 100 microvolts to 100 volts in 6 decade ranges.
(.001, .01, .1, 1, 10, 100 volts full scale)
Measurements may be made down to 40μV at reduced accuracy when employing null detector feature. Threshold sensitivity of null detector is 10 μV.

Frequency Range

10 cps to 2 Mc for voltage measurement.
5 cps to 4 Mc as bridge null detector

Accuracy

In range 100 microvolts to 100 volts:
3% from 10 cycles to 1 megacycle; 5% above 1 megacycle
at any point on the meter scale.

Input Impedance

Range Switch Setting	Input Impedance
0.001 V and 0.01 V Ranges	2 megohms shunted by 19 pF
0.1 V Range	2.2 megohms shunted by 9 pF
1 V, 10 V and 100 V Ranges	2 megohms shunted by 9 pF

Above audio frequencies shunt resistance diminishes owing to inherent properties of all resistors having finite physical dimensions.

Scales

Logarithmic voltage scale (illuminated) reading from 1 to 10;
Linear decibel scale reading from 0 to 20
Each meter is hand calibrated.

Amplifier Characteristics

Maximum voltage gain of 60 DB, adjustable by means of range switch to 40 or 20 DB. Output impedance 500 ohms. Maximum output voltage 1 volt.
Flat within ½ DB from 10 cps to 2 Mc.

Power Supply

105-125 (or 210-250) volts, 50-400 cycles, 35 watts.

Tubes

Five Type 5654; two Type OA2; one Type 6X4.
All tubes supplied.

Dimensions

Portable: 6¾″ wide, 6″ high, 10⅞″ long.
Rack Mounted: 19″ wide, 6¾″ high, 6″ deep.

Weight

11 pounds, net. Shipping weight 16 pounds.

INSTRUCTIONS FOR
BALLANTINE MODEL 310A ELECTRONIC VOLTMETER

GENERAL — This instrument is designed to measure sinusoidal voltages from 100 microvolts to 100 volts over a frequency range from 10 cycles to 2 megacycles. It operates from a 105-125 (or 210-250) volt 50 to 400 cyclé power supply.

By means of a six decade range switch, the entire voltage range is indicated on a single logarithmic voltage scale reading from 1 to 10. The meter has a uniform decibel scale numbered from 0 to 20 decibels. The zero of the decibel scale is arbitrarily arranged for maximum usefulness so as to correspond to 1 on the voltage scale.

Its accuracy is 3% up to 1 megacycle and 5% above 1 megacycle.

Although the meter zero is suppressed a switch is provided for obtaining an on-scale reading when no signal is applied to the voltmeter, and this feature permits its use as a sensitive null indicator while also providing means for measuring levels below 100 microvolts down to 40 microvolts.

An AC output jack permits the amplifier section of the voltmeter to be used as a flat pre-amplifier with gains of 20, 40 or 60 DB depending on the setting of the range switch.

CIRCUIT ARRANGEMENT — The voltmeter employs a resistance-capacity decade attenuator, two negative feedback amplifier units, a full wave crystal diode rectifier and a logarithmic indicating meter responding to the average values of the voltage wave but calibrated in rms values of a sine wave. Each of the amplifier units has sufficient feedback to render the indications of the instrument substantially independent of changes in line voltage, tubes and other circuit components. Part of the range switch attenuator is placed between the two amplifier units thereby reducing tube noise, hum and microphonics to a minimum. For further circuit details see the attached diagram.

BASIC OPERATION — The voltmeter is supplied with tubes and is ready to operate as received. It is only necessary to plug the line cord into the specified AC power source and turn on the switch marked "ON-OFF." The illuminating lamps incorporated in the indicating meter serve as pilot lights to indicate when the power is on.

The input terminal marked GND is connected to the case of the voltmeter. In order to avoid the introduction of extraneous voltages between the two points whose potential difference is under measurement, the input terminal marked GND should, whenever possible, be connected to the ground of the circuit in which a voltage is being measured.

In order to avoid extraneously induced voltages when operating on the more sensitive ranges, the input leads to the voltmeter should be as short as possible and should be shielded if the consequent increase in capacitance can be tolerated. This also applies to the binding post connections and hence it is recommended that for measurements in which the avoidence of pick-up is imperative the General Radio shielded head assembly, Type 274-ND ,be employed.

Measurements in the range 100 microvolts to 100 volts are easily made by reference to the range switch position and the reading on the single voltage scale. The position of the range switch indicates the voltage input to yield full scale deflection of the indicating meter.

For best accuracy the portable version of the voltmeter should be arranged with the scale of the meter situated in the horizontal place for which position the specified accuracy figures are applicable. A degradation of accuracy by not more than 1% may occur if the instrument is used in any other position owing to unavoidable limitations of moving coil movements. In the case of rack-mounted voltmeters the specified accuracies apply for the vertical position of the panel.

MEASUREMENT BELOW 100 MICROVOLTS AND ABOVE 100 VOLTS — Although the NULL DET switch is designed for use with AC bridges, as described below, it can be employed for extending the range of the voltmeter from 100 μV down to 40 μV. The error in this region will be no greater than 10%. Whenever the pointer falls below the scale on the .001 range, depress the NULL DET switch and note the reading in microvolts. Subtract from this reading the deviation introduced by the NULL DET switch, as described below. The resulting difference represents the voltage applied to the voltmeter input. To compute the deviation introduced by the NULL DET switch, connect a signal to the voltmeter input sufficient to obtain an up-scale reading. Any range of the voltmeter can be used, and the source can be of any frequency within the range of the instrument. Ex-

press the reading in microvolts as though the instrument was on the .001 range. Now depress the NULL DET switch and again express the resulting reading in microvolts. The difference between these two readings is the deviation introduced by the NULL DET switch.

Voltages less than 100 microvolts over the range from 10 to 150,000 cycles may be measured directly with this voltmeter by using it in conjunction with the Ballantine Model 220C Decade Amplifier.

For measurements above 100 volts (200 volts in the case of the Model 310A-S/3) the Ballantine Models 1310A and 1310B Multipliers permit an increase in range to 1000 volts and 10,000 volts, respectively.

MEASUREMENT OF VOLTAGES AT LINE FREQUENCY — Even though the amount of residual hum in the voltmeter is negligible in relation to normal measurements, it may introduce slight errors when the voltmeter is used to measure voltages giving indications at the lower end of the meter scale and having a frequency synchronous with that of the AC supply. Errors due to this condition will not exceed ½% on all range settings except the .001 range where up to 3% is possible. These inaccuracies may be reduced by making two measurements, one with the power plug in normal polarity and the other with the power plug reversed. The mean of these readings will represent the true value of the voltage being measured.

INPUT IMPEDANCE — The input impedance of the voltmeter depends somewhat on the setting of the range switch as shown by the tabulation in the specifications on page 3.

Any direct current component of the wave under measurement is kept out of the voltmeter by means of a series blocking condenser in the input circuit of 600 volts DC rating. If it is desired to measure the AC or ripple component of a wave whose DC component exceeds 600 volts an auxiliary network should be employed. This may consist of a series condenser of at least 0.15 μF (with a voltage rating at least equal to the DC component of the wave under measurement) and a resistor of at least 5 megohms in shunt. An example of the use of such a network would be for the measurement of the commutator ripple on a 650 volt DC generator.

OVERLOAD CHARACTERISTICS — The amplifier circuits are designed to saturate promptly when the voltage exceeds the full scale indication of the meter, thus protecting the meter movement. This is of considerable advantage over other meters which may be seriously damaged by overloads such as the Model 310A will withstand. Overloads amounting to several hundred to one can be safely withstood on the lower ranges, while on the 10 and 100 volt ranges the maximum safe voltage is 400 volts.

EFFECT OF WAVE FORM — The indications of this voltmeter are proportional to the average value of the AC wave under measurement. Since however, it is primarily intended to measure sinusoidal waves its calibration is in terms of the rms value of a sinusoidal wave. Since electronic voltmeters of the input diode rectifier type respond to the peak values of a wave, the readings of such a meter and the present voltmeter will not necessarily agree when harmonics are present. The amount of the discrepancy will depend on the number and magnitude of the harmonics present as well as their phase relationship with respect to the fundamental. In all cases, however, the departure of the readings from true rms values due to the presence of harmonics will be considerably less with an average responding meter such as the Model 310A than with a peak responding meter. For example, in the case of a third harmonic whose amplitude is 20% of the fundamental the maximum error of a peak responding meter may be as much as 20% whereas the maximum error of an average responding meter such as the Model 310A will never exceed 6.7%.

Inasmuch as the Model 310A voltmeter responds to the average value of the AC wave, "turn-over" discrepancies occasioned by any lack of symmetry of the wave such as are experienced in half-wave peak reading instruments are minimized, provided the crest factor of the wave does not exceed 2 when readings are being made at full scale. For lower readings the crest factor limit is increased in inverse proportion to the ratio of the reading and full scale deflection.

SCALE RANGE ADJUSTMENT — Under normal conditions a voltage which produces a scale reading of 10 will, when reduced by 90% (i.e. in the ratio of 10 to 1), produce a scale reading of 1. Ordinarily no adjustment should be necessary except at very infrequent intervals, but if some discrepancy is noted an adjustment accurate to approximately 1% may be made as follows: Allow the voltmeter to warm up for at least five minutes. Connect to the input a stable AC source of about 10 volts, of less than 1% distortion, and of any convenient frequency from 100 to 10,000 c.p.s. Adjust the amplitude so that the meter reads full scale (10) on the 10 volt range. Switch to the 100 volt range. The meter should now read 1. If not,

the red adjusting screw on the indicating meter should be rotated until it does. Switch back to the 10 volt range, to see whether the meter still reads 10. If not, readjust the input voltage to read 10 and then switch back to 1, readjusting the red screw if necessary. If it is not convenient to obtain a source of 10 volts the 1 and the 10 volt ranges may be similarly used to make this adjustment by using a source of 1 volt. (Since the input resistance of the voltmeter on the 0.1 volt range is slightly higher than on the other ranges the use of this range is not recommended in making this range adjustment unless the impedance of the voltage source is less than 50,000 ohms.)

If greater accuracy than that indicated above is desired it is recommended that the scale range adjustment be made on a single range of the voltmeter by using an external precision 10:1 potential divider which presents to the voltmeter a source impedance of not more than 2,000 ohms. The procedure would then be as outlined above except that level changes would be made with the potential divider and not the voltmeter range selector switch.

METER ADJUSTING SCREW — In the past some users have misunderstood the purpose of the red adjusting screw on the case of the indicating meter and have tried to use it either to bring the pointer to 1 on the scale with no voltage applied to the voltmeter input terminals, or to change the calibration of the voltmeter, instead of realizing that its *sole* function is to effect the scale range adjustment as described in the preceding section. The indicating meter, being logarithmic, has a suppressed zero and the normal position of the pointer with no input voltage is against the left-hand stop and off scale. The meter should indicate on scale only when a voltage within the range selected by the range switch is applied to the input terminals of the instrument (except when the "Null Det." switch is operated).

CALIBRATION ADJUSTMENT — Normally, no attention need be given to the matter of calibration as the large amount of feedback in the instrument gives it sufficient inherent stability to maintain the original factory calibration within the accuracy specified. However, to correct errors which might result from the cumulative effects of wide variations in characteristics of replacement tubes from average tubes, a variable control has been provided which allows the calibration to be shifted a small amount. Access to this control is possible with a screw-driver after removing the plug button situated on the side of the voltmeter close to the amplifier output connector.

In adjusting the calibration of the instrument the source voltage should be a *pure* sinusoidal wave of any convenient frequency from 100 to 10,000 c.p.s. and the rms indicating voltmeter used as the standard should be accurate to at least 1% at the selected test frequency.

USE AS A NULL DETECTOR — Although the Model 310A voltmeter possesses adequate sensitivity to detect unbalance voltages for most bridge measurement work, a condition may arise where the unbalance voltage will be less than 100 microvolts in which case the pointer of the voltmeter will fall below the left-hand extremity of the scale when working on the 0.001 volt range. In this contingency the null balance may be consummated by depressing the null detector switch marked "Null Det." thereby supplying a small bias current to the indicating meter and bringing the pointer to an on-scale reading even in the absence of an input signal. With this switch depressed the direct-reading feature of the voltmeter is temporarily invalidated and the instrument serves only to indicate the relative magnitudes of very low potentials in the order of 10 to 100 microvolts and in a frequency range of 10 cycles to 4 megacycles (except as discussed under "Measurements Below 100 Microvolts").

USE AS AN AMPLIFIER — Inserting a standard tip and sleeve telephone plug into the output jack marked "AC OUTPUT" automatically disconnects the indicating meter and makes the amplifier section of the voltmeter usable as a stable high gain preamplifier. When the range switch is set for the 0.001 range the gain of the amplifier is 60 DB which gain may be reduced to either 40 or 20 DB by setting the range switch to the 0.01 or the 0.1 setting respectively. The maximum undistorted output of the amplifier is 1 volt and its output impedance is 500 ohms. When fed into a load having a resistance of not less than 50,000 ohms and a capacitance of 40 to 70 pF (which may be that of the output cable) the amplifier will give a response uniform within ½ DB over the entire frequency range from 10 cycles to 2 megacycles.

The hum and noise level present at the output jack when the instrument is used as an amplifier is less than 20 millivolts on the most sensitive range (0.001 volt) and less than 2 millivolts on the other ranges. These noise levels are 34 DB and 54 DB respectively down from the maximum undistorted output voltage level of 1 volt. They are equivalent to less than 20 microvolts in series with the grid of the input tube.

POWER LEVEL MEASUREMENTS — In view of the many different applications for Ballantine Voltmeters and the prevailing differences in power reference levels, it was felt inadvisable to relate the db scale of the basic instrument to any particular level.* Accordingly, in the interest of clarity and generality, the 0 of the db scale has been set arbitrarily at 1 on the voltage scale, and 20 db, therefore, corresponds to 10 on the voltage scale.

The most frequently used power references at which a level of zero decibels is arbitrarily set are:

(1) 1 mW/600 Ω — 1 milliwatt of power corresponding to 0.775 volts across a pure resistance of 600 ohms.

(2) 6 mW/600 Ω — 6 milliwatts of power corresponding to 1.897 volts across a pure resistance of 600 ohms.

(3) 6 mW/500 Ω — 6 milliwatts of power corresponding to 1.732 volts across a pure resistance of 500 ohms.

The following table enables a ready conversion from the db reading of the Ballantine Scale to the actual zero db power level for any of the reference levels above including zero db corresponding to 1 volt.

If power reference levels other than those above are involved the Ballantine Laboratories, Inc., DB Slide Rule will be found very useful in the corresponding decibel level determinations. The slide rules are available free of charge on application to the Company.

MEASUREMENT OF CURRENT — By using Ballantine Series 600 Precision Shunt Resistors in conjunction with this voltmeter currents from 0.1 microampere to 3 amperes may be measured over a frequency range of 10 cps to 200 kilocycles with an accuracy approaching that of the voltmeter. If reduced accuracy is tolerable current measurements may be also made at frequencies up to 1 megacycle within the limits stated in our catalogue description of these Precision Shunt Resistors. The lowest Shunt available for minimizing voltage drops is 0.01 ohm, which may be used to measure currents from 10 milliamperes to 10 amperes up to 20,000 cps with an introduced error of less than 0.5%.

SERVICING — Servicing of this instrument by the user is not recommended except for the renewal of the fuse, illuminating lamps and tubes.

CAUTION

Do not remove either the V5-5654 Tube or the diode assembly 310A-X2 without first either switching the instrument off or inserting a telephone plug in the amplifier output jack. Damage to the diode assembly can result if this precaution is not observed.

WARNING

However, if attempts are made to investigate the internal parts of the voltmeter potentials as high as 400 VOLTS MAY BE ENCOUNTERED with respect to the chassis. When removing the panel from the outer case of the voltmeter unscrew only the four bright oval head screws at the edges of the panel, and not the black Phillips head screws.

REPLACEMENT OF TUBES — Maintenance of accuracy within the specified limits is dependent

*To serve those who frequently work with reference to zero dbm in 600 ohm circuits a special version Model 310A-S/1 is available with the db scale related directly to this datum.

MODEL 310A RANGE SETTING	DB TO BE ADDED TO OR SUBTRACTED FROM THE DB READING ON THE BALLANTINE DB SCALE IN ORDER TO CONVERT TO THE DESIRED ZERO REFERENCE LEVEL			
Volts Full Scale	Zero Level = 1mW-600 ohm	Zero Level = 6mW-600 ohm	Zero Level = 6mW-500 ohm	Zero Level = 1 volt
0.001	−77.8	−85.6	−84.8	−80
0.01	−57.8	−65.6	−64.8	−60
0.1	−37.8	−45.6	−44.8	−40
1.0	−17.8	−25.6	−24.8	−20
10.0	+ 2.2	− 5.6	− 4.8	0
100.0	+22.2	+14.4	+15.2	+20

on the extent of tube deterioration after the voltmeter has been subjected to extensive use. Even the stabilizing effect of negative feed-back cannot completely offset severe degradation of tube characteristics, especially when a number of tubes are involved simultaneously.

A simple test can be undertaken as follows to check the overall state of the amplifier tubes and so allow the user to decide whether tube replacement is necessary.

Insert an adjustable auto-transformer (such as a Variac) between the voltmeter and the power line. Feed a stable signal of audio frequency to the voltmeter input terminals and effect adjustments to produce an on-scale deflection. Note the change in reading as the line voltage is varied between the limits 105 and 125 volts. If the change exceeds 3% it is recommended that all amplifier tubes be checked for sub-normal transconductance.

This instrument is fitted with a lamp (Type TS47) mounted between the two 0A2 regulator tubes. The illumination from this lamp aids in the firing of these tubes under conditions of low line voltage. If the instrument exhibits excessive meter flutter after being turned on for a minute or so, check for a lamp failure. Occasionally an 0A2 tube, with aging, will become sluggish in firing even with the higher light ambient provided by the lamp, and the tube should therefore be replaced.

The failure of the meter illuminating lamps to light after the switch is turned on is an indication of either burned out lamps or a blown fuse. Access to these lamps for replacement purposes may be obtained by removing the cover of the indicating meter by unscrewing the two holding screws on the top. The fuse is located on the side of the voltmeter case through which the power cord passes. It is of the cartridge type and may be replaced without removing the voltmeter from its case by merely unscrewing the thumb screw marked "Fuse." Spare fuses are supplied but if additional fuses are required they are type 3AG, ¾ ampere, and may be ordered from any standard source of fuse supply.

Specialized techniques and highly precise calibration equipment are needed for thorough servicing of the voltmeter. It is therefore stressed that any major problem concerning its operation be reported to Ballantine Laboratories, Inc. whose engineering and repair departments will give it their prompt attention and will submit suggestions to deal with the difficulty. Give full details concerning conditions of usage, including the serial number of the voltmeter.

If, after acting on recommendations given by us, the difficulty still persists, or if the defect is clearly in the voltmeter and is not eliminated by tube replacement, the voltmeter should be returned via Railway Express packed in a surrounding of at least 3 or 4 inches of excelsior or similar material.

In the case of an instrument whose period of purchase exceeds the warranty period, a reasonable charge will be made for repairs and for replacement of faulty components including defective tubes.

WARRANTY — We warrant each instrument sold by us to be free from defects in material and workmanship. Our obligation under this warranty is limited to repairing or replacing any instrument or part thereof, except tubes or batteries, which shall, within 1 year after shipment to the original purchaser, prove upon our examination to be defective.

REPLACEMENT PARTS LIST

REFER TO MODEL 310A SCHEMATIC DIAGRAM MC-792D

B.L. PART NO.	CIRCUIT SYMBOL	CAPACITORS	MANUFACTURER
2140	C1	.047 μF, 600 v, Type 620S,	Goodall
2453	C2	0.5-5 pF, Variable Trimmer, Type 532,	Erie
2225	C3	8 pF, Type CM15C-080-J	El-Menco
2431	C4	3-12 pF, Type TS2A-3,	Erie
2404	C5	760 pF, Max., Type X305,	El-Menco
2407	C6	1600 pF, Max., Type X309,	El-Menco
2213	C7	.004 μF, Mica, Type 1W,	Cornell-Dubilier
2201	*C8	2 pF, Mica, Type CM-15-C-020-M,	Arco
2005	C9A	15 μF, 150 v, Type DFP,	Magnavox
	C9B	15 μF, 150 v, Type DFP,	Magnavox
	C9C	1000 μF, 2 v, Type DFP,	Magnavox
2040	C10	100 μF, 150 v, Type DFP,	Magnavox
2132	C11	1 μF, 200 v, Type 621M,	Goodall
2142	C12	0.1 μF, 200 v, Type 109P10492,	Sprague
2228	C13	50 pF, Type CM15E-500J,	El-Menco
2226	C14	3 pF, Type CM15-C-030M,	El-Menco
2451	C15	1-8 pF, Ceramic Variable, Type 532,	Erie
2101	C16	0.002 μF, 600 v, Type 68P22081H,	Magnavox
2005	C17A	15 μF, 150 v, Type DFP,	Magnavox
	C17B	15 μF, 150 v, Type DFP,	Magnavox
	C17C	1000 μF, 2 v, Type DFP,	Magnavox
2139	C18	.033 μF, 200 volt, Type 621S,	Goodall
2138	C19	0.1 μF, 200 volt, Type 620S,	Goodall
2503	C20	2.2 pF, Type GA,	Stackpole
2055	C21	25 μF, 25 v, Type DPE,	Sprague
2318	C22	2 μF, 200 v, PUP, −0 +10%,	Cornell-Dubilier
2055	C23	25 μF, 25 v, Type DPE,	Sprague
2055	C24	25 μF, 25 v, Type DPE,	Sprague
2018	C25	1000 μF, 10 v, Type DFP,	Magnavox
2030	C26A	10 μF, 450 v, Type DFP,	Magnavox
	C26B	30 μF, 450 v, Type DFP,	Magnavox
2029	C27	50 μF, 350 v, Type DFP,	Magnavox
2040	C28	100 μF, 150 v, Type DFP,	Magnavox
2040	C29	100 μF, 150 v, Type DFP,	Magnavox
2040	C30	100 μF, 150 v, Type DFP,	Magnavox
2232	*C31	150 pF, Type CM15-E-151-J,	El-Menco
2235	C32	33 pF, Type CM-15-E-390-J,	El-Menco
2226	*C34	3 pF, Type CM-15-C-030-M,	Arco

* The values of these items are determined during the calibration of the instrument and may differ from the values listed.

REPLACEMENT PARTS LIST

REFER TO MODEL 310A SCHEMATIC DIAGRAM MC-792D

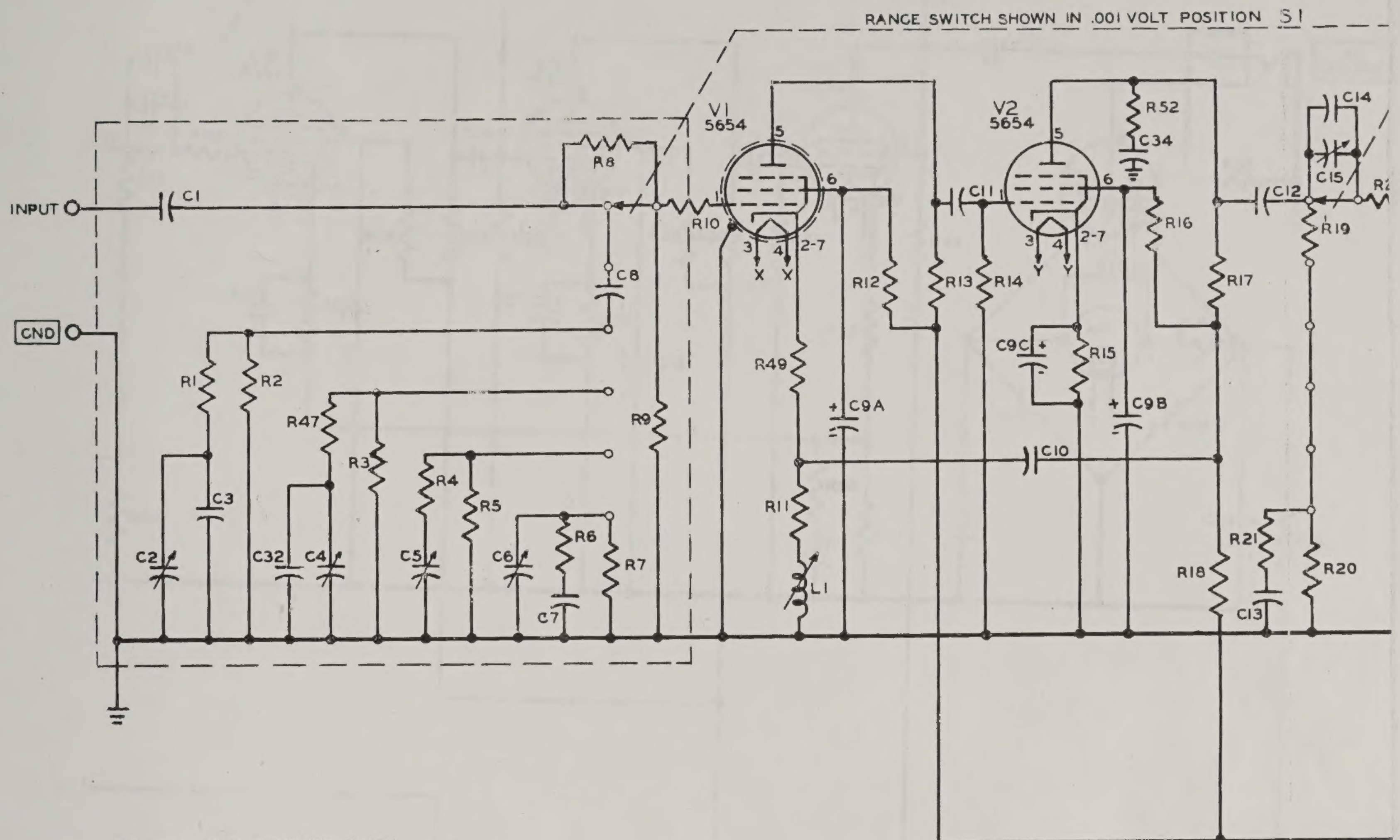
B.L. PART NO.	CIRCUIT SYMBOL	RESISTORS	MANUFACTURER
1060	R1	620 ohms, Type EB, 5%,	Allen-Bradley
1303	R2	250,000 ohms, Type CP-½, 1%,	Wilkor
1319	R3	20,400 ohms, Type CP-½, 1%,	Wilkor
1072	R4	39 ohms, Type EB, 5%,	Allen-Bradley
1335	R5	2,000 ohms, Type CP-½, 1%,	Wilkor
1260	R6	7.5 ohms, Type GB, 5%,	Allen-Bradley
1351	R7	200 ohms, Type CP-½, 1%,	Wilkor
1460	R8	2,000,000 ohms, Type CP-½, 1%,	Wilkor
1460	R9	2,000,000 ohms, Type CP-1, 1%,	Wilkor
1065	R10	200 ohms, Type EB, 5%,	Allen-Bradley
1353	R11	140 ohms, Type CP-½, 1%,	Wilkor
1041	R12	18,000 ohms, Type EB, 5%,	Allen-Bradley
1656	R13	7,500 ohms, Type N20, 1%,	Corning
1023	R14	200,000 ohms, Type EB, 5%,	Allen-Bradley
1064	R15	220 ohms, Type EB, 5%,	Allen-Bradley
1044	R16	10,000 ohms, Type EB, 5%,	Allen-Bradley
1366	R17	9,000 ohms, Type CP-½, 1%,	Wilkor
1338	R18	1,000 ohms, Type CP-½, 1%,	Wilkor
1461	R19	1,000,000 ohms, Type CP-½, 1%,	Wilkor
1308	R20	111,100 ohms, Type CP-½, 1%,	Wilkor
1060	*R21	620 ohms, Type EB, 5%,	Allen-Bradley
1065	R22	200 ohms, Type EB, 5%,	Allen-Bradley
1065	R23	200 ohms, Type EB, 5%	Allen-Bradley
1081	R24	27,000 ohms, Type EB, 5%,	Allen-Bradley
1325	R25	7,500 ohms, Type CP-½, 1%,	Wilkor
1091	R26	91,000 ohms, Type EB, 5%,	Allen-Bradley
1082	R27	240 ohms, Type EB, 5%,	Allen-Bradley
1040	R28	20,000 ohms, Type EB, 5%,	Allen-Bradley
1081	R29	27,000 ohms, Type EB, 5%,	Allen-Bradley
1325	R30	7,500 ohms, Type CP-½, 1%,	Wilkor
1010	R31	1,000,000 ohms, Type EB, 5%,	Allen-Bradley
1345	R32	400 ohms, Type CP-½, 1%,	Wilkor
1754	R33	29.5 ohms, Special, 1%,	Ballantine
1040	R34	20,000 ohms, Type EB, 5%,	Allen-Bradley
1712	R35	2,500 ohms, Type RS-2, 1%,	Dale
1814	R36	2,000 ohms, Type W-2000 Pot,	I.R.C.
1712	R37	2,500 ohms, Type RS-2, 1%,	Dale
1342	R38	540 ohms, Type CP-½, 2%,	Wilkor
1012	R39	750,000 ohms, Type EB, 5%,	Allen-Bradley
1716	R40	800 ohms, Type 5KT, 5%,	Sprague
1717	R41	3,750 ohms, Type 5KT, 5%,	Sprague
1268	R42	1,300 ohms, Type GB, 5%,	Allen-Bradley
1706	R44	3,500 ohms, Type 5KT, 5%,	Sprague
1057	R45	1,000 ohms, Type EB, 5%,	Allen-Bradley
1062	R47	300 ohms, Type EB, 5%,	Allen-Bradley
1083	R49	82 ohms, Type EB, 10%,	Allen-Bradley
1057	*R50	1,000 ohms, Type EB, 5%,	Allen-Bradley
1026	R52	100,000 ohms, Type EB, 5%,	Allen-Bradley

* The values of these items are determined during the calibration of the instrument and may differ from the values listed.

REPLACEMENT PARTS LIST

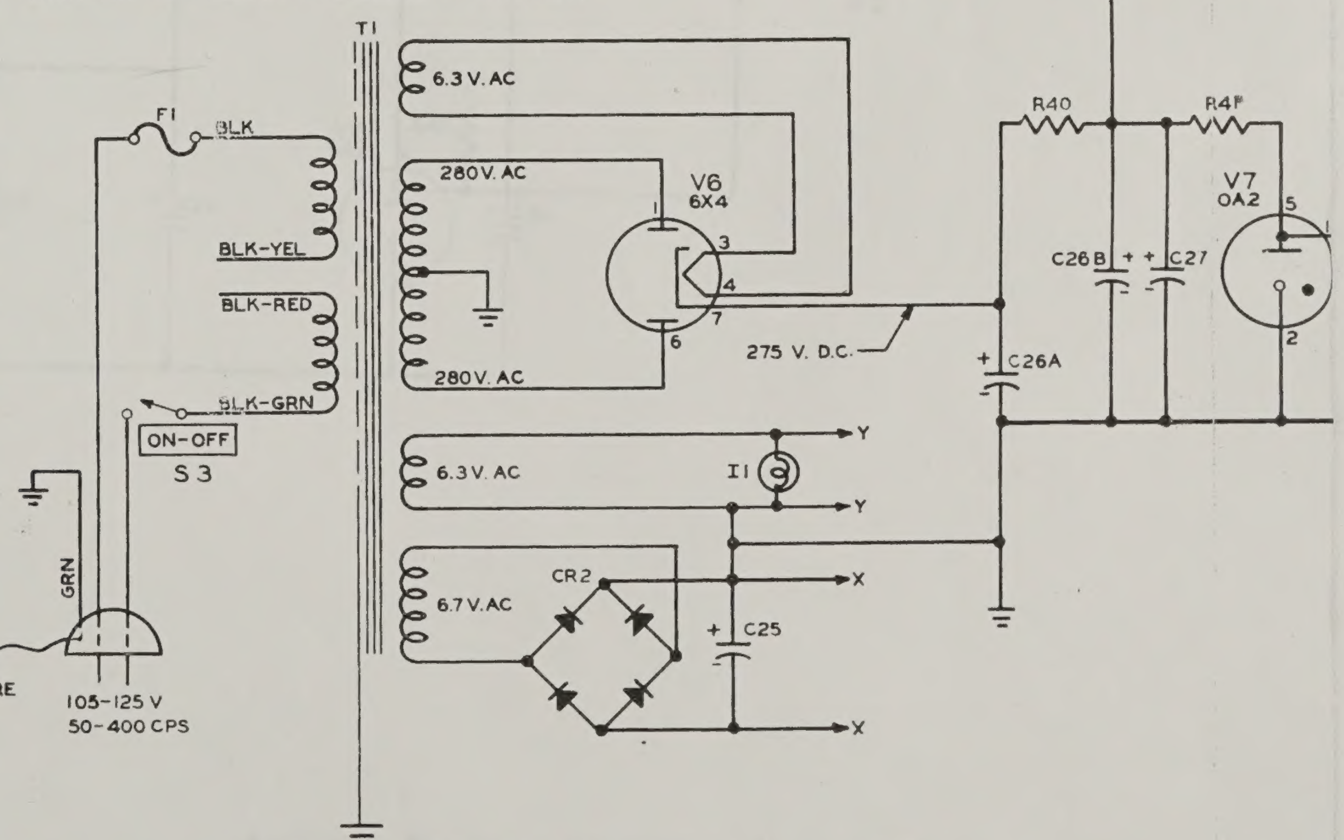
REFER TO MODEL 310A SCHEMATIC DIAGRAM MC-792D

B.L. PART NO.	CIRCUIT SYMBOL	OTHER COMPONENTS	MANUFACTURER
3006	L1	Peaking Coil,	Ballantine
3030	T1	Power Transformer, Code 79-51R,	Ballantine
3406	F1	¾ amp. fuse, Type 3AG,	Littelfuse
3451	I1	Pilot Light, Type 47,	General Electric
3162	M1	Indicating Meter,	Ballantine
3230	S1	Range Switch,	Ballantine
3268	S2	ON-OFF Switch,	Ballantine
3269	S3	NULL DET. Switch,	Ballantine
3126	V1, 2, 3, 4, 5	Type 5654 Tube,	General Electric
3105	V6	Type 6X4 Tube,	R.C.A.
3106	V7, 8	Type 0A2 Tube,	R.C.A.
3144	CR1	Crystal Diode, Type S53,	Transitron
3075	CR2	Selenium Rectifier, Type P1B1S1A,	Radio Receptor



FOR 115V. INPUT, CONNECT BLACK AND BLACK-RED TO FUSE POST; CONNECT BLACK-YELLOW AND BLACK-GREEN TO SWITCH. F1 - 3/4 AMP.

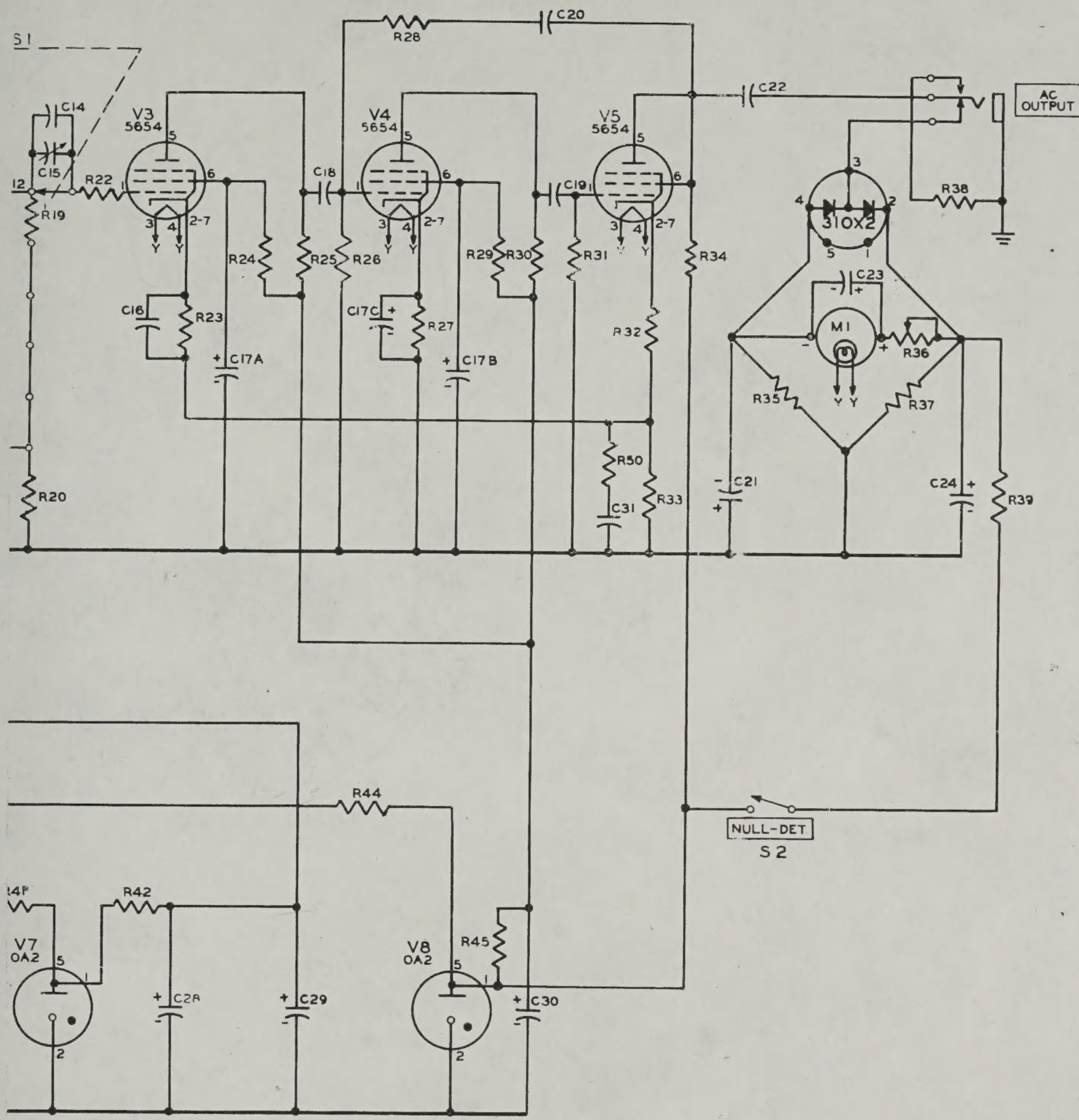
FOR 230V. INPUT, CONNECT BLACK TO FUSE POST; CONNECT BLACK-GREEN TO SWITCH; CONNECT BLACK-YELLOW AND BLACK-RED TO INSULATED TERMINAL. F1-3/8 AMP.



REPLACEMENT PARTS LIST

REFER TO MODEL 310A SCHEMATIC DIAGRAM MC-792D

PART NO.	SYMBOL	OTHER COMPONENT	MANUFACTURER
[illegible]	[illegible]	[illegible]	Ballantine
[illegible]	[illegible]	Power Transformer [illegible]	Ballantine
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Meter [illegible]	Ballantine
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	V1, 2, 3, 4, 5	Type [illegible] Tube	[illegible]
[illegible]	V6	Type [illegible] Tube	[illegible]
[illegible]	V7, 8	Type [illegible] Tube	[illegible]
[illegible]	CR1	[illegible]	[illegible]
[illegible]	CR2	Selenium Rectifier [illegible]	[illegible]



Sensitive Electronic Voltmeter Model 310A Issue MC-792D

BALLANTINE LABORATORIES, INC.

BOONTON, N. J.